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Executive Summary

The broad based US-China energy collaborations have been active for more than 25 years. Many productive projects have been executed result in US technology/equipment/services being adopted in China with financial and environmental benefits for both the US and China. As China's economy expects to grow at double digits for the foreseeable future, there are more critical needs and opportunities for US-China collaborations in energy and environment industry. After 10 years, the US/China Energy and Environmental Technology Center (EETC) has successfully established a solid foundation in the US and China for further promoting China's adoption of US clean energy technology, equipment, and services with emphasis in clean coal technology for power generation, transmission, and emission reductions supported by the US Department of Energy (DOE). EETC has been supporting the Protocol on Cooperation in the Field of Fossil Energy Technology Development and Utilization in developing additional tasks between the US DOE and the Ministry of Science and Technology (MOST) of the People's Republic of China. EETC supports the US led effort of the Carbon Sequestration Leadership Forum, and is implementing bilateral projects with China.

EETC is working with the DOE and other government agencies including US Environmental Protection Administration, US Trade and Development Agency, and the Asia-Pacific Partnership (APP) with goals geared toward the expansion of collaboration and transfer of more US clean energy technologies (e.g. coal mine methane utilization, carbon capture and sequestration, and energy/steam optimization) to China for emission reductions. EETC also leverages its resources and works on clean energy projects supported by Asian Pacific Economic Cooperation (APEC,) Atlantic Council, and Natural Resources Defense Council, Shell Foundation etc. In the next five years, EETC plans to support new US clean energy projects for development, demonstration, and fully commercial deployment in China such that the US technology can bring full environmental benefits. The Green Olympic Games in 2008 in Beijing and the 2010 World Expo in Shanghai present unique opportunities for US businesses, especially the small and medium sized business.

Background

The broad based US-China energy collaborations have been active for more than 25 years. China has actively participated at, and contributed to, the US led programs including International Partnership for Hydrogen Economy and International Thermonuclear Experiment Reactor. Many projects have resulted in US technology/equipment/services being adopted in China with financial and environmental benefits for both the US and China. For example, the US Department of Energy (DOE) supported "Energy Conservation Building" at the Ministry of Science and Technology (MOST) completed in 2004 successfully introduced the US Green Building code into China along with the construction technology, equipment and material. Similarly, the successful demonstration of the US DOE supported geothermal pumps in Beijing has opened China's market to the US vendors. As another example, the annual US-China Oil and Gs Industry Forum is proven to be a productive platform with more ad more industry participants ear after year Very recently, Westinghouse's AP 1000 Nuclear Power Stations have begun constructions in China which is another successful example of US-China collaborations. Since both the US and China depend heavily on fossil energy, we actively promote and implement fossil energy related collaborations.

Brief History of EETC

The U.S./China Energy and Environmental Technology Center (EETC), was officially established in 1997, to facilitate the development of friendly, broad-based U.S./China relations. The US headquarters of EETC is located at Tulane University and its Chinese headquarters is located at Tsinghua University, Beijing with the US/China Clean Coal Technology Center (1999) branches located at the China Coal Research Institute in Beijing and Shanghai (established in 2003.) In addition to strong US industry partnerships, EETC signed the Memorandum of Understanding with the National Research Center for Coal and Energy of West Virginia University in 2005 for a broadly based cooperation that helps to promote the deployment of the US clean energy technologies and joint ventures for sustainable development in China.

The center's major goal is to enhance the competitiveness and adoption of U.S. clean energy and environment technology in China and to advance efforts to protect local and global environments through the use of such technology, especially the clean coal technology for power generation, transmission, and emission reductions supported by DOE. Efforts to decrease global environmental impacts associated with China's substantially rapid growth in the past decade are paying off. EETC has established a broad based government-industry-academic partnership in China that is both friendly to the US and a strong partner in global sustainable development. This partnership is essential in advancing the goals and objectives of the Asian Pacific Partnership (APP) in China.

EETC was funded initially by the US Department of Energy (DOE) and the US Environment Protection Agency (EPA), with contributions from the private sector. China's State Science and Technology Commission (now the Ministry of Science and Technology or MOST) cost shares EETC's operation at Tsinghua University. In the past, the EETC's projects have received funds from the National Resource Defense Council and Shell Environment Initiatives. Lately, EETC

derives its funding mainly from DOE, but we will prepare proposals to EPA's Methane to Market Program on Coal Mine Methane, US Trade Development Agency on Low NOx technology, and Clean Development Mechanism for energy/steam optimization with emission reduction for additional funding opportunities.

EETC is accomplishing its mission to promote the efficient, responsible production and utilization of energy, and to encourage environmental performance, while improving the quality of life in China. Specifically,

Operations

Co-Chaired by Dr. Eamon M. Kelly, President emeritus of Tulane University and Professor Shi Dinghuan, Counsellor of the State Council and former Secretary of MOST, with eminent board members from the US and China governments, industries, and academics, the US/China Advisory Board of the US/China Energy and Environmental Technology Center (EETC), advises the EETC management team which is headed by Dr. S. T. Hsieh, the US project manager, on policy, planning, and project execution. Dr. S. T. Hsieh, with the support and guidance of the Office of Clean Energy Collaborations, Office Fossil Energy, DOE, oversees the day-to-day operation with the assistance of a team of Tulane supporting staff and a team of external subcontractors and/or consultants. The Tulane management team also supervises the subcontractors in China, mainly Tsinghua University, EETC's headquarters in China headed by Professor Wu Zongxin, Counsellor of the State Council.

Successful Strategies include:

- Establishing an expanding and strong US industry partnership with a focus on small and medium sized business
- Cultivating local advocates: identifying, developing, and supporting projects and policy development of interest to both the US and China stakeholders
- Developing & maintaining productive relationships at all levels in China Emphasizing education & training, and outreach, stressing the financial, as well as, technical aspects of projects.

Services

EETC has established a unique working team assisting US industry partners to penetrate the vast Chinese market via business planning, matchmaking, project development, contract negotiations, and financing. We now have channels able to promote projects to the decision makers at all levels in China. The EETC continues to coordinate education and training programs, technical seminars and provide the following services:

- Coordination and support of the management of US/China business interests;
- Project development support with a focus on commercial projects;
- Market evaluation and strategic planning;
- Coordination and support of US/China government agency activities;
- Technical and economic feasibility studies;
- Finding business partners and identifying financial resources;

- Hosting of conference, workshops, and information tours; and,
- Cross-culture training.

Major Initial Activities

Integrated Gasification Combined Cycle (IGCC) for Power Generation

Most of the advanced Clean Coal Technology for power generation is capital intensive in which a few industry players in the world are qualified. For example, the most advanced and clean technology for power generation, the front-end investment for Integrated Gasification Combined Cycle (IGCC), currently cost at least $1,000/kw, which is almost double the cost of a traditional coal fired power plant without advanced environmental control devices in China. The EETC team has been promoting IGCC in China since 1994, before the EETC was officially established. From 1994 through 1996, we first created a critical mass of an US/China government-industry-academia team to initiate IGCC. Tulane University hosted the first US/China IGCC Seminar wherein all key US industry representatives presented their technology/equipment to a high-level Chinese delegation. A site tour was conducted at the then largest IGCC facility at Louisiana Gasification Technology, Inc. In order to gain support for the techology, "The USA and the PRC Experts Report on Integrated Combined Cycle Technology" was published in English and Chinese in 1996. The report was circulated to the highest levels in China. In order to maintain the momentum of moving the project along during the long consensus-building process, we continuously worked with the interested parties by leveraging more than $500,000 in public and private funds to perform tasks that consistently promote the US based IGCC technology and equipment. We frequently hosted Chinese visitors to US sites, organized seminars/workshops, eliminated communication gaps, addressed issues of concern, and removed barriers. Since financing is a major concern for the IGCC projects, we constantly kept the then Ministry of Electric Power and State Power Corp. (SPC), now the five nation-wide generation companies and the two national grids, in touch with the World Bank, Asia Development Bank, US Ex-Im Bank, and other potential funding agencies. For the US technology/equipment vendors including GE, EETC helps them stay updated on China's implementation plan and procedures.

A solicitation for the 300-400 MW IGCC Yantai project in Shandong Province was issued on January 28, 2002 with a budget of around $300-400 million. However, the bid cost was double the budget, so China has changed its implementation strategy. As of now, China's industry has joined the US led FutureGen project, and is implementing China's GreenGen project in parallel. China is very interested in collaborating with the US on understanding the operation experience of US IGCC projects and the R&D for the next generation technologies.

Coal Liquefaction

In 1996, the EETC matched Hydrocarbon Technologies, Inc. (HTI, now acquired by Headwaters), an employee-owned small business in New Jersey, with the Chinese partner, Shenhua Corporation, the largest diversified energy group in China. Under DOE's support, HTI developed direct coal liquefaction technology. EETC has successfully:

Facilitated the formation of a US-China team with the best partners:
Coordinated meetings that completed a Letter of Intent, Cooperative Agreements and a prefeasibility study.

Maintained the momentum of the project by hosting/participating in meetings:
Assisted capital fund raising and USTDA support for a feasibility study.
HTI and Shenhua settled the IP issue for ~US$5,000,000 in October 2003.

Currently, Senhua's Coal liquefaction project (valued at US$3 Billions) is ready to be on line around 2008 with several US firms actively participating.

Flu Gas Desulfurization (FGD)

Acid rain is a major threat to the environment, China estimates that damage to its environment and human health translates into economic losses nearing110 billion Yuan ($13.3 billion) annually. More than 21 million tons of SO2 were emitted in 2003 and 22.5 million tons in 2004. The US has developed effective equipment to control acid rain in coal fired power plants. EETC actively promoted the US technology to China, as early as 1998, and co-sponsored the US-China Workshop on SOx Control Technologies in the US.

In 2001, EETC supported the Babcock & Wilcox's (B&W's) bid for Zhejiang Qian-Qing Power Plant 125 MW FGD project which was successfully on-line in October 2003. By November 2003, B&W secured more than 15 GW of retrofit projects in South China alone. All new power plants in China are required to include FGD now, and B&W's wet FGD technology is considered a standard. As of November 2005, after the licensing agreement with B&W was signed in August 2002, China's Kaidi has sold and installed 16,070 megawatts (MW) of scrubber capacity. Of this total, in 2004, Kaidi received orders to install B&W's environmental equipment on eight contracts in China totaling 7,470 MW. By the end of 2005 Kaidi has received orders for an additional four contracts totaling 3,600 MW.

Supporting the US/China Protocol/Annexes and Other Relevant Activities

EETC has provided continuous support (logistic, communication, meeting management etc.) for the Protocol on Cooperation in the Field of Fossil Energy Technology Development and Utilization (Protocol) between the US DOE (Office of Fossil Energy) and the Ministry of Science and Technology of the People's Republic of China which was signed in 2000 in Washington DC. Under the Protocol, there are five annexes: Annex I deals with clean power generation; Annex II deals with clean fuels (for transportation); Annex III deals with oil and gas; Annex IV deals with (post combustion) environmental science and technology; and, Annex V deals with Climate science. EETC has actively coordinated/managed DOE-MOST meetings and developed specific tasks under these annexes to include clean power, clean fuels, oil and gas, and environmental controls. EETC has been actively supporting the annual US-China Oil and Industry Gas Forum since its inception.

For example, in 2001 EETC staff worked with DOE staff, US experts and the Chinese counterparts developed a training course on Natural Gas, and in November of 2003 the Coal Bed Methane (CBM) and Coal Mine Methane (CMM) (respectively under Annex III). EETC's US industry partners include Gas Technology Institute and Advance Resources Inc. Under Annex IV, there is going to be the 3rd NOx/SO2 and Multipollutant Control Workshop in Beijing late October, 2007. EETC is actively supporting a project to explore the process specific Carbon

Capture and Sequestration opportunities at Shenhua's Liquefaction project site under Annex II currently managed by West Virginia University.

EETC also leverages its resources and works on clean energy projects supported by Asian Pacific Economic Cooperation (Demand Side Management, LNG etc.) Atlantic Council (US-China Energy Security Dialogue), Natural Resources Defense Council, and Shell Foundation (retrofitting small coal fired fertilizer plants in China.)

Supporting the Asia-Pacific Partnership (APP)

EETC activities are well suited to enhance the effectiveness of the APP in China. In addition to the networks and partnerships mentioned above, project activities, both ongoing and proposed, in carbon capture and sequestration (CCS). Activities in developing and utilizing coal mine methane resources (CMM), and energy/steam optimization projects are areas of interest to the APP, and will provide experience and information to both Chinese and APP partners critical to the partnership's goals.

Recent Activities and Initiatives

Recently, under the able direction of the DOE Management Team and the guidance of the Advisory Board, EETC has been implementing the following initiatives to improve the environmental performance and energy efficiency in China.

1. Promoting US NOx Technology in China

The Chinese have expressed special interest in the most advanced US NO_X Control technologies such as the highly effective and inexpensive selective non-catalytic reduction (SNCR) technology/equipment. One project co-funded under the DOE-MOST Clean Fossil Energy Protocol (Annex IV) is focused on the feasibility study of US technology for a green field project. The projects has been completed and a US vendor id get the contract for implementation. Funding by the US Trade & Development Agency (USTDA), National Energy Technology Laboratory (NETL), EETC and US EPA support/facilitate the "Feasibility Study for the Environmental Emissions Control Project in China at Beliun Power Plant." The project focused on retrofitting technologies. The approach centered upon a typical large Chinese power plant and completed a pre-feasibility study by mid-2005 addressing a range of technology options. This allowed a broad assessment of the potential market for all relevant US technologies.

EETC's US industry partners include H&J, Advanced Burners (acquired by Siemens,) and Advanced Combustion Technology (ACT www.advancedcombustion.net), who are developing a strategy for the deployment of US equipment/services in China. We are actively developing follow-up activities in the US with Tsinghua University, the Pan-China Technology Investment Consulting Co. Ltd., and the Electric Power Technology Market Association of China.

2. Improving the environmental Performance of Small Industry (Stoker) Boilers

Supporting the US-China 2008 Beijing Olympics Protocol, EETC funds a project for Beijing Institute of Coal Chemistry ((BRICC), the manager of the US/China Clean Coal Technology

Center), China Coal Research Institute, to improve the environmental performance of small industry boilers in the Beijing area.

In China, small & medium size industry (stoker) boilers consume a significant amount of coal each year and significantly contribute to air pollution. Stoker-fired boilers account for approximately ¼ of the coal consumed in China. These boilers are operated by industrial, institutional, and commercial coal customers, and are numerous in China, precluding their wholesale replacement in the near-term. Centralized coal management for small users has caught the attention of Chinese administrative authorities recently. It is not only a good energy conservation measure but also an important means for reducing pollution from coal-related combustion. The US has good experiences in centralized management and quality control for small coal users. These experiences have been introduced to Chinese governments, at the local level in particular. Especially Beijing is more stringent in coal management, and can use the US experiences in a greater degree due to the 2008 Green Olympics. The project expanded when EETC introduced its US partner, Louisiana Steam Equipment Co. (LSE) (www.steamsolutions.com) to BRICC. LSE has steam/energy optimization technology/equipment/service that can further reduce the emissions with improved efficiency. LSE and BRICC are discussing joint demonstration of LSE's equipment and joint ventures, possibly including the (ESCo) concept for delivering energy service in China.

BRICC has already been offered retrofit projects in Shanxi and Liaoning provinces, outside the greater Beijing area. A US-China workshop is scheduled for September 20, 2007 to introduce the accomplishments of the project including the benefits of reduced emission. BRICC is expected to make a full scale national push in cleaning up the industry boilers in China.

3. Carbon Capture and Sequestration (CCS)

This joint U.S.-China Study of CO_2 sources and sinks in China is the first and major joint U.S.-China effort on Carbon Sequestration. It complements the Carbon Sequestration Leadership Forum (CSLF) and is an area of great interest to the APP. This project will characterize the technical and economic potential of CO2 capture and storage technologies in China. The goal of the project is to compile key characteristics of large anthropogenic CO2 sources (including power generation, iron and steel plants, cement kilns, petroleum and chemical refineries,) as well as candidate geologic storage formations that exist across China, and to develop estimates of geologic CO2 storage capacities in China. The two-year project is managed by Leonardo Technologies, Inc., with sub-contract relationships with Battelle Memorial Institute and Montana State University using a methodology developed under the auspices of the IEA Greenhouse Gas R&D Programme. The project is expected to be completed by September 30, 2008.

We are also developing a comprehensive US-China joint research agenda, expanding the US Regional Carbon Sequestration Partnership concept in China, and introducing the Research Experience in Carbon Sequestration program (RECS 2007) with EnTech to China. China has committed to send two scientists to attend the RECS 2007 from July 30-August 10, 2007.

EETC is actively supporting a project exploring the process specific Carbon Capture and Sequestration opportunities at Shenhua's Liquefaction project site under Annex II (Clean Fuels) managed by West Virginia University.

4. Supporting the deployment of Zero-Emission Technology

EETC developed a broad industry partnership including Powerzinc, a California based firm, which has made a breakthrough on the Zinc-Air Fuel Cell Battery. EETC has been promoting a major demonstration project which may include up to 50 e-buses powered by Powerzinc's Zinc-Air Fuel Cell Batteries in Shanghai. It has the potential of revolutionizing the global transportation industry because it is absolutely emission and nearly noise free.

5. Coal Mine Methane (CMM) and Coal Bed Methane (CBM) Projects

China is the most active coal producer in the world with its coal industry being the most dangerous in the world with mine methane explosions as the major problem. As such, China has focused on air ventilation of coal mine methane with an large amount of the methane emitted from its coal mines. China emits 8~10 Billion cubic meters of CBM and Coal Mine Methane (CMM) each year, but only 500 million cubic meters or so are utilized. It means a waste of roughly one billion US dollars a year without considering the environmental impacts. China needs the know-how and equipment for purifying and processing CMM/CBM. Because China's coal industry is dominated by small coal mines, it will need the operational experience of small independent CBM/CMM projects. Further, China lacks a national gas pipeline grid; it will need innovative approaches to move the methane to markets where the price of clean energy is at a premium.

Despite international support and national efforts, China's CBM industry is merely emerging, and as such can not be considered an established business yet. For example, on May 18, 2006, the EPA announced that with direct assistance from EPA and other federal partners, Caterpillar Inc., a US based engine manufacturer, has been awarded a $58 million contract from China to supply power generation equipment for the world's largest coal mine methane fueled power plant fueled . Moreover, on December 21, 2004, the Asian Development Bank (ADB) announced that it will help develop a power plant to harness the methane produced from coal mining in the southern part of Shanxi Province through a loan approved for $117.4 million for a 120-megawatt power plant. The capital cost of $1,000/kw is extremely high, and can not compete with most clean coal fired power plants. For example, a 1000 MW, ultra super critical plant including FGD and SCR in China at cost about $600/kw.

EETC and the China Petroleum and Chemical Industry Association (CAPCIA) have been expanding their collaborations based on the successful Natural Gas Training Program and the Coal Bed Methane (CBM) training in 2002 and 2003 respectively. These programs were funded by Annex III (Oil & Gas) under the US-China Clean Fossil Energy Protocol.

Since November 2003, EETC has been engaging the Wuxi Yongda Group (Yongda, www.yongdagas.com) which hosted the CBM workshop on follow up actions. Yongda has signed long term contracts with at least 10 townships (off the supply area of the major West to East Gas Pipeline) building the local gas distribution systems and providing gas for local industries and households. Because China does not have a national gas grid, Yongda depends upon trucking LNG. Yongda has commercial operational experiences with storage, transportation, and re-gasification systems.

On June 10, 2004 EETC coordinated CPCIA's official visit to the US Trade Development Agency (TDA) in Washington, DC. TDA is particularly interested in funding detailed economic analysis of the proposed CBM/CMM project. On June 23, 2004 EETC signed a MOU with Shanxi Energy Industry Group (SEIG) in Taiyuan focused on purifying and liquefying Shanxi CMM. EETC visited Hebi, Henan late April, 2006. The US team was hosted by the Hebi Coal Industry (Group) Corp. Ltd. and the Hebi Coal & Electricity Company Ltd. In order to further develop the US industry partners, EETC and Milestone Consulting LLC visited CMME at Portland, Oregon in August 2006. As such the US China project team with upstream, downstream, US CBM/CMM technology and operational experience is complete. In the mean time, EETC is exploring CMM opportunities in Shanxi province, Shaanxi Province and Guizhou Province, respectively. EETC's focus is to structure demonstration projects with public-private funds to showcase the cost effectiveness and environmental performance of the US extraction, purification and utilization technology and equipment. EETC will work with industry partners to take the successful demonstration into China's market place as a self-sustained business.

Planned Activities for the Next Five Years

During the next five years, EETC will follow its established strategy supporting the development and deployment of US clean energy technology/equipment/services in China to contain the global environmental impacts of China's economic expansion. First, EETC will focus on the following basic tasks

- Continue support to the US-China Protocol/Annexes focused on developing and executing tasks supported by additional resources
- Support the US-China collaboration on the Green Olympic Games in Beijing and the 2010 World Expo in Shanghai
- Actively support the Carbon Sequestration Leadership Forum and Zero Emission Technology.
- Actively participate in and support tasks of the Asia-Pacific Partnership.
- Further develop the industry partnerships with US businesses, especially small and medium sized businesses

Specifically, in response to China's national agenda EETC will develop and implement the following projects and activities.

China's national goal is to reduce environment pollution by 10% during the China's 11th five-year plan (2005-2010), and in clean fossil energy China is focusing on:

- Continuously promoting IGCC Power Generation Technology. China's 11th five-year plan includes at least three IGCC demonstration projects. China requests support in technology selection, operation & maintenance training, and engineering evaluations.
- Continuously promoting environmental control technology/equipment for conventional coal fired power plants.
- China has implemented dust control and flue gas desulphurization technologies, and China will focus on the deployment of NOx control technology and R&D on Mercury control & PM2.5 control as well as multi-pollutants control technology.

China's national goal is to improve energy efficiency by 20% during China's 11th five-year plan (2005-2010)

- EETC will continue to work with US industry partners to implement energy optimization demonstration projects with Energy Service Co. (ESCo) concept as a business model.

The State Power Grid Corporation will invest a record 220 billion yuan ($28.6 billion) in fixed assets this year, of which 202.5 billion yuan ($26.3 billion) will be poured into construction, company sources announced on Monday. (Xinhua News Agency March 6, 2007)

- China's power grid critically needs technical upgrading to ensure grid security and that no major blackout could occur, to improve efficiency, and to reduce emissions. EETC has initiated a US-China working team to facilitate technology/equipment/service transfer with workshops in China and site tours in the USA.

Carbon Capture and Sequestration (CCS) technologies do exist, and, if implemented broadly, can mitigate the environment impacts of fossil energy consumption which is essential for sustaining the global economy growth.

EETC will support bi-national or multi-national capacity building, knowledge transfer, education and training in China. Such activities will include R&D on reducing CO2 capture costs, site selection, technical risk assessment, characterization, and monitoring, measurement and verification. EETC will support the identification of early deployment opportunities in China such as enhanced oil recovery, and post-combustion CO2 capture for coal fired power plants. EETC will continue to promote and implement a US-China Joint Research CCS agenda to reduce the cost of CO2 separation and capture. EETC has initiated US-China team meetings for Chinese Academy of Sciences, Tsinghua University and the National Research Center for Coal and Energy, West Virginia University.

China has an interest in emulating the Regional Carbon Sequestration Partnership. EETC plans to work with US partners such as the Southern States Energy Board, University of Wyoming, Montana State University, West Virginia University and national laboratories to develop a corresponding Chinese team for knowledge transfer.

Support China's national energy statistics and auditing system.
China is in fast transition as such; the national system for energy statistics, energy auditing, energy pricing, energy legislation and enforcement has yet to be established. The energy related data base is crucial for policy development including energy security and transparency. The US system and operational experience are valuable for China to fully develop its national system. EETC has implemented workshops at Tsinghua University in 2006 focused on US energy legislation process and the impact of EPACT 2005 in partnership with the US Energy Association. EETC will continue to work with the US and China teams to enhance China's capacity.